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EVALUATION OF AN AUTOMATIC DEVICE  
FOR SCORING NYSTAGMUS

Gene T. Turnipseed, Ralph M. Jell, and Fred E. Guedry, Jr.

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NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY  
PENSACOLA FLORIDA

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<p>Turnipseed, G. T. R. M. Jell, F. E. Guedry, Jr.</p> <p>EVALUATION OF A SIMPLE DEVICE FOR SCORING NYSTAGMUS. NAMRL-1260. Pensacola, FL: Naval Aerospace Medical Research Laboratory, 15 May.</p> <p>Quantitative scoring of vestibular nystagmus can be expensive and time consuming. Quantitative computer scoring of nystagmus offers attractive, timesaving economy for both research and clinical applications. This report evaluates a relatively simple and inexpensive nystagmus velocity computer.</p> <p>Ten nystagmographic recordings of caloric responses were scored by the nystagmus velocity computer and compared with scores obtained by a proven but more time-consuming method. The results of this evaluation indicate that the computer provides timesaving and reasonably accurate quantitative scoring of these records. The evaluation revealed certain precautions that should be taken in the use of this equipment.</p>	<p>1979</p> <p>Nystagmus</p> <p>Caloric</p> <p>Nystagmus scoring</p> <p>Computer scoring</p>
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PENSACOLA, FLORIDA 32508

## SUMMARY PAGE

### THE PROBLEM

Quantitative scoring of vestibular nystagmus can be expensive and time consuming. Quantitative computer scoring of nystagmus offers attractive, timesaving economy for both research and clinical applications. This report evaluates a relatively simple and inexpensive nystagmus velocity computer.

### FINDINGS

Ten nystagmographic recordings of caloric responses were scored by the nystagmus velocity computer and the results compared with scores obtained by a proven but more time-consuming method. This evaluation indicates that the computer provides timesaving and reasonably accurate quantitative scoring of these records. It also revealed certain precautions that should be taken in the use of this equipment.

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## INTRODUCTION

Quantitative computer scoring of vestibular nystagmus offers attractive, timesaving economy for both research and clinical applications. Fairly complex systems have been proposed to provide the versatility required for research applications (1,2,4), while more restricted, relatively inexpensive commercial systems suitable for some clinical applications have become available. This report describes an evaluation of the Instrumentation and Control Systems, Inc., Nystagmus Velocity Computer, Model NCO-100, which fits into the latter category and is an instrument that can be used to score nystagmus during some laboratory tests.

## PROCEDURE

### MATERIALS

Calorically induced electronystagmograms from ten normal individuals were used as a basis for the evaluation. These records had been recorded on magnetic tape at the time of the test. Five of these records were judged by visual examination to represent good quality nystagmus tracings, and the other five were judged to be of poor quality. Two records were synthesized using a waveform generator, and represented noise-free nystagmus.

### APPARATUS

A Phillips mini-log 4 portable analog cassette recorder was used to play back horizontal eye movement recordings made during earlier caloric tests. It uses standard tape cassettes and has four FM data channels. Tape speed was 0.75 inch per second and bandpass was 0-250 Hz. Eye movements were written continuously on chart paper, using a Hewlett-Packard Model 7754A thermal strip chart recorder. This is a 4-channel recorder designed specifically for medical applications. A medium gain Model 8802A preamplifier was used with the recorder, and an electrical signal output was taken from one channel to provide an input to the NCO-100 system.

The Instrumentation and Control Systems, Inc., Model NCO-100 Nystagmus Velocity Computer processes preamplified eye movement signals (derived from the corneo-retinal potential) and digitally displays the average slow phase eye velocity for successive sets of nystagmus beats. It uses a time-weighted averaging technique, with each beat representing a percentage of the whole, depending on beat amplitude and duration. It is designed to average the slow velocity component of ten beats and display the value, and continue to the next group of ten beats of nystagmus until the test is ended. A memory subsystem automatically stores the highest average ten-beat velocity encountered during the test. This value can be called and displayed at the end of the test.

The NCO-100 requires a full-scale input of from 5 to 20 volts, peak to peak. The maximum available output of the H-P 7754A recording system is only  $\pm 2.5$  V, and, therefore, it is too low to interface with the NCO-100. A Texas Instruments type

SN 72747 dual general purpose amplifier with a gain of 5 was used to boost the H-P 8802A preamplifier output to an acceptable level for the NCO-100. It should be noted that Instrumentation and Control Systems, Inc. (ICS), manufactures a recorder and a caloric bath that readily interface with the NCO-100. Thus our interfacing circuit was necessitated by the decision to use our own recorder.

The Electromechanical Slope Computer (ESC) provided a system for comparative scoring (3). This device performs a semi-automated score of chart recorded nystagmus, and employs computer-aided printout and plot of slow phase slope. It affords considerable timesaving relative to unaided manual measurement, but is not potentially as fast as the NCO-100. The ESC has been modified since its introduction and now incorporates a tangent function potentiometer to generate slope measures and a Digital Equipment Corporation PDP-8 computer to calibrate the signal. A Teletype Corporation ASR-33 outputs the data.

## METHOD

Many of the caloric tests administered in this laboratory have been recorded and stored on cassette tapes. A set of five good quality records and a set of five poor quality records were selected from among these tapes. Original strip charts stored in the folders of ten subjects were reviewed to make the selections.

The complete test plan included the following:

1. Comparison of ESC scoring with NCO-100 scoring of "perfect nystagmus" generated by a Servomex waveform generator, Model No. LF51MK11.
2. Comparison of ESC scoring with NCO-100 scoring of nystagmus that had been generated in caloric tests.
3. Comparison of ESC scoring by two independent scorers (ESC-1 and ESC-2).

To make valid comparisons between ESC scoring and NCO-100 scoring, it was necessary to identify segments of records scored by the latter system. A pulse signal was located in the NCO-100 which marked off segments scored. This signal was used to deflect a marker pen on the strip chart nystagmus record so that average velocity values displayed by the NCO-100 could be matched to ESC-scored segments. The circuitry of the NCO-100 is designed to count ten consecutive nystagmus beats and to compute and display the average slow phase velocity for this ten-beat segment. This process repeats for each ten-beat cycle. Finally, the score from that cycle yielding the highest score is retained and displayed.

The entire record of each of ten caloric responses was scored. Each record was divided into a number of ten-beat scoring segments as determined by the pulses from the NCO-100 (range of segments per record was 21 to 35); three mean slow phase eye velocities were determined for each segment, two by the individuals using the ESC and the

other by the NCO-100. Scoring began at the end of the irrigation period and ended after the response had reached its maximum value and was well into the decay period.

## RESULTS

Table I shows correlations (Pearson Product-Moment) between mean slow phase eye velocities in each of the 21-35 intervals as derived by the three scoring methods for each caloric record and for the two waveform generator records. Records 1 through 5 were recordings of poor quality, whereas 6 through 10 were of good quality. Records 11 and 12 were "perfect nystagmus" as created by a waveform generator. In general, the NCO-100 versus ESC-1 and ESC-2 correlation values were lower than the ESC-1 versus ESC-2 values. Examples are shown in Figures 1 and 2. As would be expected, all correlations were highly significant statistically. The correlations were somewhat lower for the poor quality recordings than for the good quality recordings. Scores of artificial nystagmus in Records 11 and 12 were practically identical for all three methods. When all ten caloric records were considered, the correlations between ESC-1 and ESC-2 were significantly higher ( $p < .01$ ) than the correlations between NCO-100 and ESC-1 or ESC-2 (Wilcoxon Sign Test).

Table II affords an interesting comparison of intervals in which peak slow phase eye velocity occurred as determined by ESC-1, ESC-2, and NCO-100. The peak interval for the NCO-100 was sometimes discrepant from the peak interval for the ESC scores which by contrast were exceptionally well matched. Because peak slow phase velocity is frequently used for determining ear differences and/or a directional difference and because the final score displayed by the NCO-100 is its peak score, such errors, though infrequent in our evaluation, may be important. However, in our sample of data, with only one or two exceptions, the scores in the peak intervals were not substantially different.

## DISCUSSION

The results of this evaluation of the ICS Model NCO-100 velocity computer indicate that it does provide a timesaving and reasonably accurate quantitative score of vestibular nystagmus generated by caloric irrigation. Comparison with Electromechanical Slope Computer (ESC) scores, which incorporate human judgment, indicates that it is primarily with records involving extra-nystagmic saccades and non-nystagmoid waveform patterns that the NCO-100 system may yield discrepant scores.

There are, however, certain problems that may be encountered with its use. Several conditions are stated in the instruction manual for proper use of the NCO-100 computer, such as 1) calibration of the computer, 2) eye movement calibration, and 3) requirements for minimum and maximum slow and fast phase eye velocity. These instructions (in some cases, limitations) must be adhered to for accurate scores.

The NCO-100 requires a full-scale output of 5 to 20 volts, peak-to-peak from the recorder with which it is intended to interface. This voltage level is not available

Table I

Pearson Product-Moment Correlations between Scores of Record Segment\* Obtained by Two Individuals Using the ESC and by the NCO-100

Record No.	N*	NCO vs. ESC-1	NCO vs. ESC-2	ESC-1 vs. ESC-2
1	24	.65	.68	.99
2	27	.86	.89	.99
3	21	.95	.93	.98
4	35	.93	.90	.96
5	35	.94	.93	.97
6	28	.96	.95	.99
7	24	.97	.97	.99
8	21	.99	.99	.99
9	23	.99	.99	.99
10	22	.95	.95	.99
11	21	.99	.99	.99
12	24	.99	.99	.99

p < .001 for all cases

\*N refers to number of 10-beat segments within the record scored.

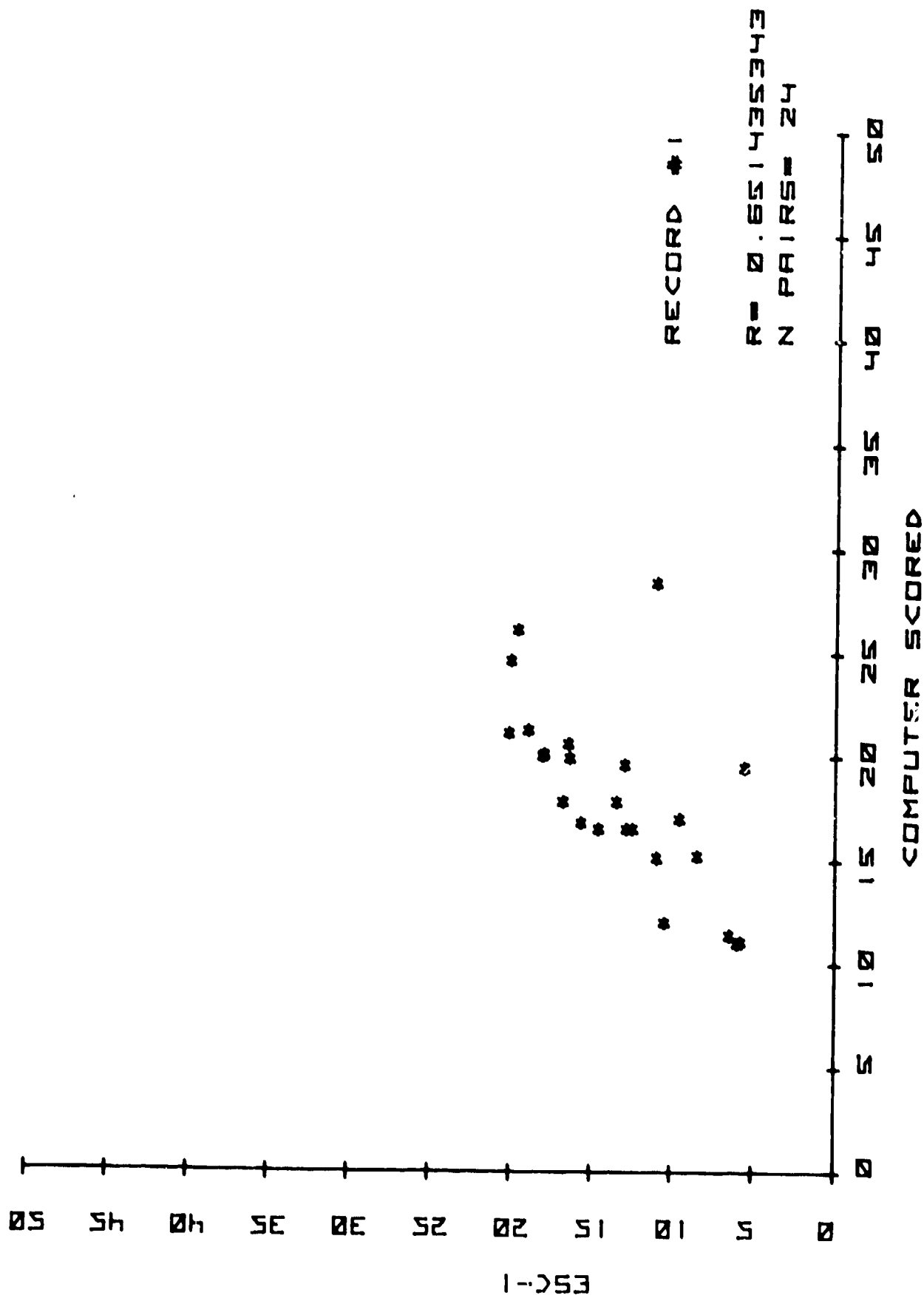


Figure 1

Comparison of scores by the computer method versus the ESC method for a poor quality record

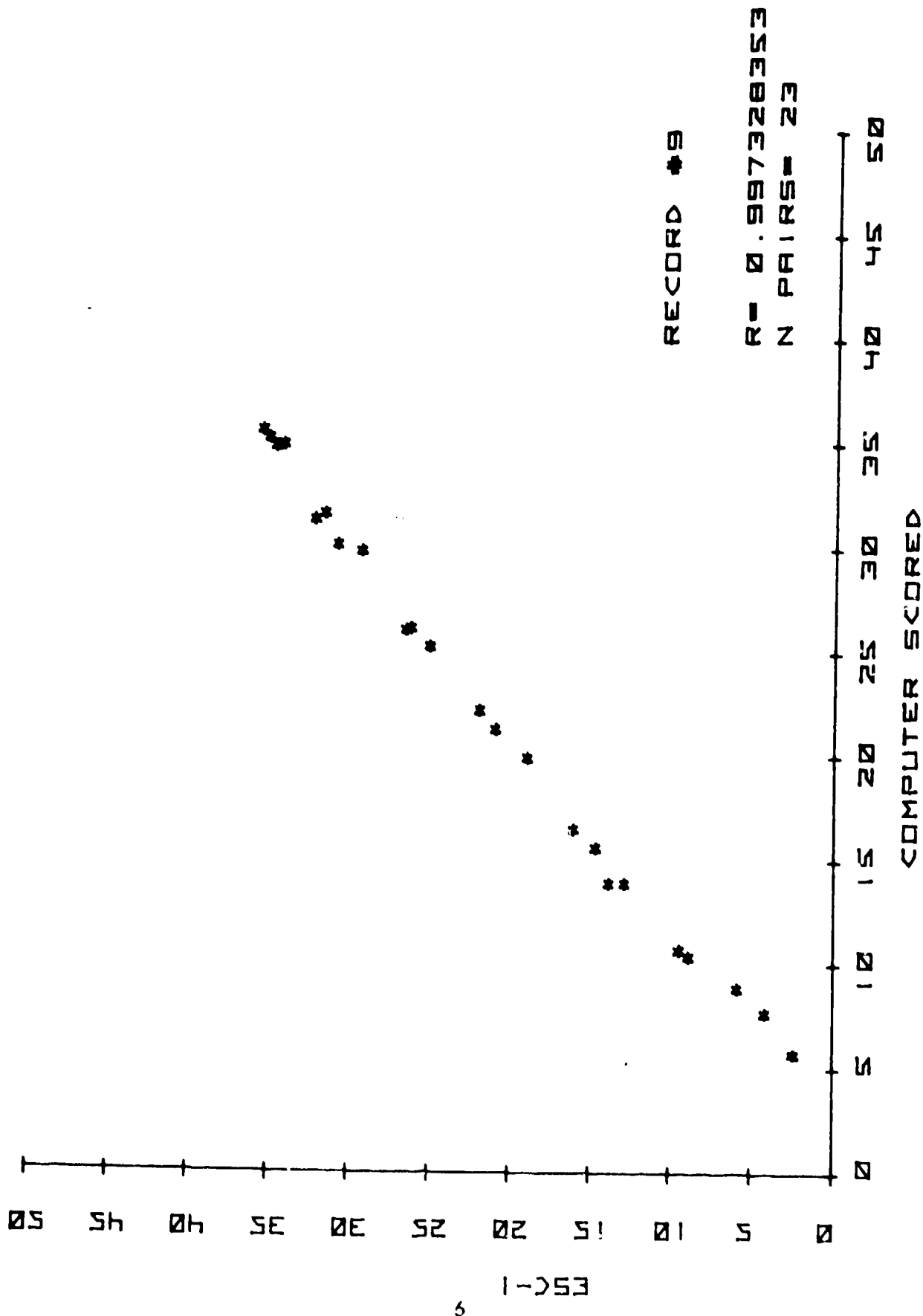


Figure 2

Comparison of scores by the computer method versus the ESC method for a good quality record

Table II

Scoring Interval in Which Peak Slow Phase Eye Velocity Was Found  
and Corresponding Velocity Values (deg/sec)

Record No.	NCO-100		ESC-1		ESC-2	
	Interval	Eye Velocity	Interval	Eye Velocity	Interval	Eye Velocity
1	15	28.4	4	20.2	4	20.6
2	10	44.3	4	39.9	4	40.1
3	10	48.8	9	44.2	9	44.8
4	13	32.0	19	34.7	19	32.3
5	8	21.3	8	19.3	8	19.3
6	12	39.9	12	44.5	12	43.7
7	9	48.1	9	43.6	9	45.1
8	6	40.5	6	38.6	6	39.8
9	11	35.7	11	35.6	14	36.0
10	5	21.7	10	20.0	10	20.8
11	20	29.7	20	28.5	20	29.2
12	22	35.1	22	33.6	22	33.6

on all recorders, and in our case a small DC amplifier was needed to achieve the required output level. In laboratories where electronic services are not available, this feature could present a problem which, however, could be avoided by using the ICS matched recording system.

During our evaluation of the NCO-100 computer we used some recordings of poor quality in order to test the computer's accuracy with the kinds of records that are frequently obtained in practice. It was found that most high frequency noise, i.e., 60 cycle and EMG potentials, did not adversely affect the scoring. The one area that did reduce the accuracy of scoring was saccadic eye movement artifacts. In almost every case where saccadic interruption of uniform nystagmus occurred, the NCO-100 would indicate a higher value of slow phase eye velocity than had actually occurred (Figure 1). This influenced some peak values of slow phase eye velocity and, as indicated above, could be misleading, since the peak value is the value that would ordinarily be used.

Also, it should be noted that the NCO-100 will give substantial scores on patterns of eye movements, e.g., square waves from eye movement calibrations, that involve no nystagmus at all. For this reason alone, visual inspection of records being scored is essential to the reasonable use of this device. Use of the NCO-100 would be facilitated if it generated a pulse that could be used to deflect a marker pen at the end of each scored segment on the strip chart of nystagmus. This segment-marker modification, which we used, is relatively easily and inexpensively accomplished. Perusal of the record for saccadic interference and other similar artifacts would then permit selection of the appropriate interval for handscoring, or by the NCO-100 if the record were on tape. Pen deflections marking off ten-beat intervals could also be used to provide estimates of nystagmus beat frequency; i.e., ten divided by the time between markers could be used as an index of mean beat frequency for each interval. However, the NCO-100 counts some very small saccades as nystagmus fast phases, and therefore, frequencies so obtained may appear higher than frequencies derived by manual scoring.

If the limitations of the ICS NCO-100 nystagmus velocity computer are recognized and precautionary measures employed, then the instrument can provide a relatively accurate, quick, and inexpensive method of scoring vestibular nystagmus within a typical time course and beat frequency produced by caloric stimulation.

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